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Improving esthetics after Silver Diamine Fluoride (SDF) treatment – Need of the Time!

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Abstract

Background: Silver diamine fluoride (SDF) is a non-invasive, low-cost, antibacterial solution that has been introduced to potentially arrest active carious lesions. However, poor aesthetics is the main disadvantage, as it causes black staining on treated teeth.

Aim: This study aimed to compare the ability of two different materials, Glass Ionomer Cement (GIC) and Giomer, to mask the discolouration caused by SDF on extracted deciduous molars.

Materials and methods: Twenty carious primary molars indicated for extraction were selected and allocated to two groups. The samples in Groups 1 and 2 were restored with GIC and giomer, respectively, after SDF application. Colour measurement was done using a Spectrophotometer and compared between the two groups. The data were subjected to statistical analysis. The level of significance was assessed at p value less than 0.05.

Results: A statistically significant difference (p=0.001) was observed in the colour masking efficacy of Group 1 and Group 2, and the intergroup comparison also revealed statistically significant findings.

Conclusion: This study found that both materials had significant masking abilities and reduced the discolouration caused by SDF application.

Keywords: Silver Diamine Fluoride, Giomer, Glass Ionomer Cement, Colour masking ability, Spectrophotometer.

1. Introduction

Early childhood caries (ECC), formerly referred to as nursing bottle caries and baby bottle tooth decay, is a significant public health problem [1]. The traditional conservative treatment of dental caries involves an elaborate process which includes mechanical preparation by removal of dental caries followed by a suitable restoration. However, this conventional method is anxiety-provoking in young children resulting in behaviour management challenges in the dental operatory. Therefore, dental treatment of uncooperative children involves advanced behaviour management techniques such as conscious sedation and general anaesthesia, which themselves have potential side effects in young children [2].

Silver Diamine Fluoride (SDF) is one of the preventive interventions that can be used as an alternative to traditional restorative procedures. It was first approved for use in Japan in 1969, but it gained renewed interest after receiving approval from the U.S. Food and Drug Administration (FDA) in 2014 [3]. SDF is a clear liquid material used to prevent the formation and spread of dental caries. It is a safe, painless, and non-invasive alternative to traditional fearful cavity drilling procedures. SDF is available in different concentrations for medicinal use, such as 12%, 30%, and 38%. The 38% concentration is effective for dental use [4]. However, one major disadvantage of SDF, like other silver compounds, is that it can cause black staining on the carious lesion due to the oxidation of ionized silver into metallic silver. These stains limit their clinical use in the aesthetic zone, particularly for demanding patients [5,6].

Since 2016, extensive research has been conducted to identify potential ingredients or techniques that can be used to address the discolouration issues caused by SDF [7]. Chemical salts like Potassium Iodide (KI) and Glutathione have been suggested as possible solutions as they form neutral compounds with silver. Additionally, immediate, or delayed restoration using various restorative materials after SDF application has also been reported as a possible solution. To address the esthetic concerns of parents and children related to the discolouration caused by SDF, the present study aimed to compare the colour masking ability of Glass Ionomer Cement and Giomer in SDF-treated carious extracted deciduous molars.

2. Materials and methods

The present pilot study was conducted in the Department of Pediatric and Preventive Dentistry to seek an appropriate solution to reduce and mask the discolouration caused by SDF application using two different restorative materials.

2.1 Sample size [8]

Sample size estimation was done by using GPower software version 3.0. A minimum total sample size of 20 was found to be sufficient for an alpha of 0.05, power of 80%. Total sample size was further divided as 10 in each study group.

2.2 Materials

In this in vitro study, 20 caries-affected primary molars indicated for extraction were collected and divided into two groups. One group received Glass Ionomer Cement restoration (GIC) (Ketac Molar, 3M Corp., Minnesota, USA) after SDF (e-SDF by Kids-e-Dental, USA) application. The second group received Giomer restoration (Beautifil® II by Shofu Dental Corporation, Osaka, Japan) after the SDF application. In both groups, the restoration was performed immediately after the application of SDF (e-SDF by Kids-e-Dental, USA).

Silver Diamine Fluoride (SDF) is a colourless liquid with a pH of 10, 24.4-28.8% (253, 870 ppm) volume of silver, 5.0-5.9% fluoride (44,800 ppm), and ammonia [4].

Giomer is a fluoride-releasing, resin-based dental adhesive material that comprises pre-reacted glass (PRG) fillers. PRG fillers are fabricated by the acid-base reaction between fluoroaluminosilicate glass (FASG) and polyalkenoic acid (PAA) in the presence of water resulting in the formation of a wet siliceous hydrogel [9,10]. Giomer is available in both flowable and bulk-filled consistency in injectable syringe form.

Glass Ionomer Cement (GIC) is available in the powder-liquid system. Both the powder and liquid are mixed manually. The powder is mainly fluoro-aluminosilicate glass, and the liquid is an aqueous solution of polyacrylic acid. Polyacrylic acid is copolymerized with carboxylic acid, maleic, tartaric, and itaconic acid to regulate the viscosity and stabilize the liquid [11].

2.3 Specimen preparation

The extracted teeth were stored in deionised water till the time of use, and they were rinsed thoroughly using sodium hypochlorite before mounting in self-cure acrylic resin (DPI, India) [9].

All the extracted teeth were mounted using self-cure acrylic resin using a PVC tray to ensure that the full carious lesion was visible. SDF was then applied to the carious lesion with a micro brush for at least one minute [12]. Following SDF application colour measurement was done using Spectrophotometer (T_0) in each sample.

The samples in Group 1 were restored with Glass Ionomer Cement after the SDF application. The powder and liquid of GIC were mixed as per the manufacturer's recommendations, and the mix was restored (Figure 1). The samples in Group 2 were restored with Giomer (Figure 2). Adhesive available with Giomer kit was applied with a micro brush after SDF application and light cured. Giomer was then applied incrementally followed by light-curing for 20 seconds. The colour measurement of the samples was done post-operatively using a spectrophotometer (T_1).

2.4 Colour Measurement

The colour measurement was done using a Spectrophotometer (Figure 3) (Advance 5.0 VITA Zahnfabrik, Bad Sackingen, Germany) in both the groups at baseline, after SDF application (T_0), and after restoration (T_1) in each group. The French CIELCh system was used for the calculation of the colour change (ΔE), which is a colour space defined by the "International Commission on Illumination" (abbreviated CIE) in 1976. It expresses the colour as three values, L* indicates lightness, C* represents chroma, and h is the hue angle [13].

The use of the Vita Easy Shade spectrophotometer (Figure 3) is an appropriate tool for objectively identifying colour changes that cannot be visualized by the naked eye. The colour changes could be studied effectively because of the numeric data generated from the sound and lesion-affected area. The L*, C*, and h* values were measured to calculate ΔL, ΔC, and Δh. Then, the extent of the colour change (ΔE) was assessed. Colour measurement done at baseline (T_0 - refers to the time after application of SDF) and after restoration (T_1) in respective groups. Each time colour was measured under constant laboratory illumination by positioning the spectrophotometer at three different sites on the samples, and an average of the three measurements was used for data analysis [13].

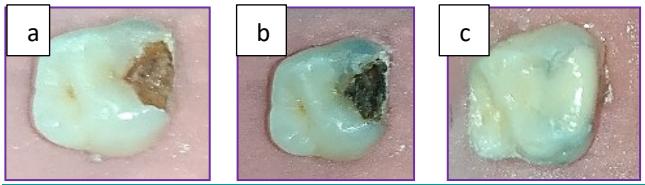

Figure 1. Study procedure in Group 1. Where a. Preoperative, b. After SDF application, and c. Restored with GIC.

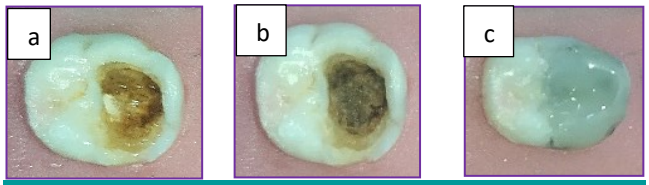

Figure 2. Study procedure in Group 1. Where a. Preoperative, b. After SDF application, and c. Restored with Giomer.

Figure 3. Vita Easy Shade Spectrophotometer.

2.5 Statistical analysis

The obtained data were subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS, version 21.0, SPSS Inc., Chicago, IL, USA). The importance of analysis parameters between the groups was identified by t-test (intergroup analysis). A repeated t-test was used to classify the importance of the research parameter in the groups (intragroup analysis). The p-value less than or equal to 0.05 was considered statistically significant.

3. Results

The mean and standard deviations of ΔE of both groups are presented in Table 1. This study evaluated and compared the colour-masking ability of GIC and Giomer after restoring the SDF-treated carious teeth. Results showed that GIC exhibited superior colour masking ability in comparison to Giomer restorative material. A significant difference (p=0.001) in ΔE between before and after restoration in both groups was observed (Table 1). On intergroup comparison (Table 2), the difference in colour masking ability of GIC and Giomer showed statistically significant (p=0.001).

Table 1: ΔE after SDF application and the restoration in both the groups

	Group – I (Restored with GIC)		Group – II (Restored with Giomer)	
	Mean ΔE ± SD*	P - Value	Mean ΔE ± SD*	p - Value
After SDF application (T_0)	545 ± 22.7	0.001	467 ± 26.7	0.001
After Restoration (T_1)	440 ± 55.3		398 ± 48.6	

Table 2: Intergroup of ΔE

	Mean ΔE ± Standard difference*	p - Value
Group – I (Restored with GIC)	105±19.88	0.001
Group – II (Restored with Giomer)	69±21	

4. Discussion

SDF application has a caries-preventive effect and decreases the incidence of new lesions [14]. The effect of SDF is found to be associated with its antibacterial properties and chemical reactions with hydroxyapatite. Unfortunately, the blackish discolouration of the tooth attributed to the formation of silver was the most discouraging drawback, irrespective of the concentration used [15]. The black staining is a potential disadvantage, but the parents favourably select SDF over invasive technique as it is painless and safe [16]. Younger children are relatively more receptive to SDF use than older children [17]. Recently various methods have been utilized in masking this effect of SDF including the application of silver precipitating agents or simply restoring with an opaque material [18]. A promising approach used to solve this problem is applying the KI solution immediately after SDF treatment to decrease the resultant black colour by forming a white precipitate [19]. A variety of different restorative materials have also been introduced to restore the cavitated teeth following SDF application (with or without KI), such as glass ionomer restoration, resin-modified GI (RMGI) and resin composite restorations [20].

GIC is the most used restorative material in Pediatric Dentistry due to its fluoride-releasing properties and ability to form a good marginal seal with tooth structure [19]. GIC is the preferred material for SMART restorations because it is the only restorative material that is water-based and has a significant anticaries effect with less recurrent decay at the margins and adjacent surfaces [21,22]. The present study also showed significant masking ability of GIC over SDF discolouration (ΔE = 440). Hamdy D *et al.* found that GIC had a satisfactory masking effect on the colour change associated with the application of SDF [23].

Giomer represents one of the most recent developments in fluoride-releasing dental restorative materials, combining esthetics with the possibility of having a finished surface and good mechanical resistance. Clinical studies suggested that the morphology, marginal adaptation and post-operative sensitivity are similar for resin composites and Giomers [10]. Itota *et al.* [24], Abdel-Karim *et al.* [25] and Cury *et al.* [26] have found that secondary caries is less frequent. Considering all these advantages, Giomer was used in this invitro study to explore its ability to mask discolouration, and it showed significant results (ΔE = 398). To the best of our knowledge, Giomer has not been used to mask and reduce SDF discolouration.

Vita easy shade spectrophotometer has been used in this study to calibrate the ΔL, ΔC, and Δh values. The device has multiple applications such as shade selection for restoration, crowns, and measuring the L*, C*, and h* or Lab values for comparison. In 2008, Da Silva *et al.* [27] and in 2002, Paul *et al.* [28] compared visual and instrumental shade-matching methods. They found colour matching by a spectrophotometer is more reliable than the visual method. The present study used GIC and Giomer as restorative materials and compared their colour-masking ability in SDF-treated carious extracted deciduous molars. Based on the results obtained after statistical analysis from this in vitro study, significant colour differences were observed with the restorations following SDF applications in both groups (ΔE = 440, $p<0.05$; ΔE = 398, $p<0.05$) depicting the effective colour masking ability of both materials in SDF-treated teeth. The intergroup comparison also showed a significant difference with GIC restoration showing better masking of discoloration caused by SDF application than Giomer restoration.

Robert *et al.* [29] found that light-cured restorative materials such as resin composite and resin-modified GIC demonstrated a greyish discolouration immediately after the SDF application. Lou *et al.* [30] reported that silver iodide ions are photosensitive. Further, Zhao *et al.* [16] also reported accelerating the production of black metallic silver on exposure to heat and light. Rafaat *et al.* [31] found that the resin-based restorative material is a less effective, technique-sensitive, and expensive alternative material in masking discolouration. Hence, this could be the possible reason for the better masking ability of GIC over Giomer after SDF discolouration in carious teeth in the present study. According to Toopchi *et al.* [32], applying curing light during SDF treatment of carious lesions induces more silver ion precipitation in infected dentin, increases its hardness, and, perhaps because more silver stays in the infected dentin, less SDF penetrates into sound dentin.

Current American Dental Association (ADA) clinical practice guidelines on nonrestorative treatments for carious lesions include the application of 38% SDF, and these are often used

in conjunction with restorative treatments but do not recommend specific restoration (Slayton *et al.* 2018) [33]. Significant aesthetic barriers limit the widespread acceptance of SDF by parents. Especially, there has been a paradigm shift in expectations from advanced dental care focusing highly on aesthetic outcomes.

In current times, both the parents and children are more concerned about esthetic appearance. The recent Pediatric Dentistry paradigm is shifting towards Minimally Invasive Dentistry. SDF is one of the ways to achieve this in young children in routine practice. SDF is a novel caries arresting and preventing agent introduced in Pediatric Dentistry having a major disadvantage of permanent blackish discolouration of teeth, limiting its use among patients concerned with esthetics. However, the present study has shown a possible way of using GIC and Giomer restoration over SDF-treated teeth. Both the GIC and Giomer can be used efficiently to mask the discolouration caused by SDF application.

6. Conclusion

In this in vitro study, Glass Ionomer Cement and Giomer both showed significant masking abilities and reduced the discolouration caused by SDF application. GIC showed significantly better masking ability compared to Giomer and can be used as a suitable method to alleviate the aesthetic concern associated with SDF.

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